RESEARCH OF THE DEPARTMENT OF AGRICULTURE ON PROCESSING OF MEATS

P. A. Wells
Eastern Utilization Research Branch
Agricultural Research Service
U.S. Department of Agriculture
Philadelphia 18, Pennsylvania

Research on the utilization of meat and meat products now being conducted by the United States Department of Agriculture has the broad objective of improving the products available to the consumer and of increasing the consequent return to the farmer and processor through the development of better methods of processing and preservation. To bring about this broad objective, research is directed both at enlarging our existing knowledge of the basic chemical and biological characteristics of meat and at the solution of practical problems in the meat field. I shall attempt in this presentation to give you a brief glimpse of some of the work in progress, of a few of our past accomplishments, and of our plans for the future.

The work of the Meat Section of the Eastern Utilization Research Branch is carried on in laboratories at Beltsville, Maryland. There, an incomparable supply of animals of known breeding and feeding history is available through co-operation with the Animal and Poultry Husbandry Research Branch of the Department. Well equipped laboratories for research in the basic sciences are available, augmented by excellent pilot plant facilities for slaughtering, chilling, freezing, curing and manufacturing research. For convenience in discussing the program I should like to divide it into three phases: research concerned with meat curing, meat freezing, and the processing of meat products. Of course, I am sure you understand that this is only a very arbitrary division and that research on such factors as the physico-chemical properties of protein, for example, which is carried out by a group working on problems related to sausage manufacture, has equal application to all phases of the program.

Work on meat curing has centered largely on problems related to curing by farmers, locker plant operators, and similar groups who are not in a position to carry on their own research and must, of necessity, look to the Department for new ideas and clearly defined techniques. In this connection, we were able to develop, in co-operation with the Maryland Agricultural Experiment Station, a systematic procedure for the regional injection, or stitch pumping, of hams that would yield a product showing salt and moisture distribution as uniform as that obtained by means of artery pumping. In working out this procedure we used a sampling technique developed several years ago, by means of which selected ham slices are separated into their component muscle cross sections. It is interesting to note in passing that salt, moisture and no doubt other substances are often distributed in meat within anatomical boundaries and that adjacent ham muscles, for example, often differ widely in salt content. This fact, although hardly new, is often overlooked.

The curing of bacon presents problems that involve both curing and freezing techniques. These problems arise from our seasonal hog production and are largely connected with fat stability. If the bacon sides are held in freezer storage prior to curing, as is common in the industry, the accelerative effect of salt on rancidity is avoided. There is, however, the problem of loss due to freezer burn and shrinkage, which will be referred to later. In addition, during the storage period the bacon fat oxidizes to some extent. This is not noticeable at the time of curing, but nevertheless the fat already has moved well through the rancidity induction period.

If the bacon is cured and then stored after smoking, a practice common to farms and locker plant operators, the accelerative effect of salt on rancidity

is unavoidable. This effect has long been recognized, and because it causes bacon at freezer storage temperatures to become rancid more rapidly than green bellies, the impression has grown, and is widely held, that cured bacon should never be stored in freezers. However, bacon stored at above freezer temperatures becomes rancid or deteriorates in other ways even more rapidly, because like other enzyme reactions the enzymatic oxidation of fat proceeds more rapidly at higher temperatures. In addition, molds and bacteria flourish at higher temperatures and speed up deterioration of the fat as well as the protein.

Recent work at Beltsville, which is not yet complete, seems to indicate that bacon stored in the freezer for six months is more acceptable flavorwise than that stored at either 40°F. or 70°F. for a similar period. It is also true that bacon stored at ambient temperatures often develops a very desirable aged type of flavor that is probably due to the hydrolytic action of certain mico-organisms. The exact nature of the changes taking place, the identification of the causative organisms, and the relationships between substrate, microbe and flavor must all be exaclty determined before control measures can be devloped to the point of producing such a product with any degree of certainty.

In evaluating the experiments on curing and storage of bacon, and in much of our other work, an objective method of determining the degree of fat degradation that will be comparable to organoleptic changes, as well as a means of recognizing incipient rancidity, would be highly desirable. We have therefore directed a considerable part of our effort in that direction with some hope of success. Preliminary results now indicate that there is a volatile di-carbonyl fraction which is formed during rancidity development. It can be separated as phenylhydrazones and measured spectrophotometrically. The relation of various carbonyl compounds to the total carbonyls formed during the course of oxidation also shows promise as an analytical approach, particularly in differentiating the types of rancidity peculiar to cured and uncured pork. Should our hopes of developing a useful method materialize, it will be made available through publication as soon as possible.

In the brine curing of meats, particularly hams and shoulders, bacteria play a significant role in regulating the amount of nitrite ion available for color fixation and also contribute to flavor development. In order to better understand the changes taking place, we have correlated the changes in bacterial population with the changes in the salt, nitrite and hydrogen ion content of the brine. Nitrate reduction gradually increases during the curing process until the salt content becomes sufficiently low, due to absorption by the hams, to permit the growth of certain gram negative bacteria that rapidly reduce both nitrate and nitrite to nitrogen. Beyond this point, which usually occurs in about 45 days in long brine cures, there is no advantage to continuing the curing process.

In the course of these studies, bacteria have been isolated and a large collection of cultures is now under study in the laboratory. These organisms all prefer moderate salt concentrations for growth (about 5 per cent) and very few are obligate halophiles. It is very interesting to note, however, that only 41 per cent of those isolates which were motile in the presence of salt retained their motility in its absence. Furthermore, the ability to reduce nitrates was lost by 75 per cent of the nitrate reducers when grown in sodium choloride free nitrate broth. Thus we see that there are bacterial enzyme systems, too, that are catalyzed by sodium chloride.

In recent years the rapid expansion of meat freezing has been of interest to all of us in the livestock and meat field. The work of our meat research group at Beltsville in this area has been reported to you on at least two occasions in the past, and I will restrict my remarks today to cover only some of our more recent accomplishments and future plans.

Some time ago we mentioned the problem of meat (particularly green belly) shrinkage during freezer storage. We know that this shrinkage, which causes a considerable loss to the industry each year, is dependent upon several factors. Composition of the meat, type of exposed surface, protection by wrapping or other means, coil/room temperature differential, and probably other factors all play a part. An exact quantitative knowledge of these factors and their relationships is not, however, available. To arrive at a better understanding, a co-operative project is now being developed between our Branch and The Refrigeration Research Foundation under which we will attempt, with the

help of TRRF funds, to investigate some of the factors mentioned. Particular attention will be given in the new project to methods for controlling freezer shrinkage which lend themselves to automatic application and which can be used to advantage by the processor concerned with the preservation of wholesale cuts. As a prerequisite to this, however, the project must of necessity begin with certain basic investigations into the rates of moisture loss from frozen meat held at various temperatures, humidities and air velocities.

By making use of the wide variety of freezing conditions available in our Beltsville laboratory we have already learned much about freezing rates at various temperatures. Freezing curves for several methods of freezing at various temperatures have been determined and the effects of various wrapping materials on freezing and thawing studied. Since these results have been published I will not dwell on details at this time. It is worth noting, however, that in our freezing curves for meat, a critical point or break occurred between 28° and 30°F., a fact that confirms several earlier determinations of the freezing point of meat.

In certain of our experiments on frozen meat it became evident that pork kept in freezer storage in evacuated tin cans was more desirable after 1 year at 15°F. than comparable samples stored six months at 0°F. but wrapped in cellophane. This result not only emphasizes the necessity for preventing oxidation of freezer-stored meat but also suggests that it may not always be necessary to maintain low temperature. In the event of sudden shortages of electric power during emergencies, adequate techniques for proper freezer storage at temperatures above 0°F. would be of considerable value. We therefore are experimenting with packaging in various gases in sealed tin plate containers at both high and low freezer temperatures to determine the effects on meat quality and bacterial flora. Even more important than the practical application of this work is the fact that we hope from these samples to learn more about the mechanisms of degradative changes occurring during freezer storage.

An important aspect of the utilization research program is the investigation of meat products such as lard and sausage with the object of improving our knowledge of the basic physical and chemical reactions on which their processing is dependent. This research should in time establish a better basis for developing the technology of these products and lead to more profitable utilization of many livestock products.

Research on lard has had a prominent place in this program. One project on lard dealt with low-temperature rendering. As a background, you will recall that we had even fewer answers to the surplus lard problem several years ago than we have now. We, as well as others, carefully considered ways of improving the status of lard.

We fully appreciated the important bearing that rendering has on the quality of lard which reaches the consumer. You may recall that around 1950 several new rendering processes were developed to varying degrees of perfection. These offered alternatives to rendering mainly by heating. Such procedures were introduced as very fine comminution, enzyme treatment, and disintegration by alternate compression and decompression with steam—all innovations primarily aimed at producing a more bland lard.

Technical information on the new "modified" rendering processes was lacking. Such a situation inevitably slows the adoption of improved methods and deters the development of further improvements. Consequently, work to obtain data on basic operations appeared worthwhile and was begun. Information was obtained and published on the effects of grinding, heating and filtering under various conditions on the yield and quality of the product. We have used these results in advising a number of processors interested in improved rendering, so we know they have been applied to practical problems.

Another of our fields of interest is that of meat product manufacture. This work is conducted for the specific purpose of improving the utilization of fat, meat and meat by-products in certain types of meat products. It is concerned with both applied and fundamental problems.

Work has been completed on one practical problem, that concerned with the chemical determination of added moisture in sausage. This was undertaken at the suggestion of a group representing the packing industry and was done in collaboration with them. The specific problem was determining the variance of added moisture determinations normally used in control and regu-

lation. When completed, the results obtained in this study were used, together with data from industrial sources, to review governmental practices pertaining to the regulations of added moisture.

A second, more fundamental, project is one concerned with the basic factors affecting the production of processed products, such as frankfurters and bologna. Sausages are among the oldest forms of processed foods. Currently sausage making is an art, not a science. We anticipate that great advantages will result from establishing a more scientific basis for making these products. A great number of facts will have to be ascertained to accomplish this. So far we have undertaken research concerned with (1) determining the binding quality of different muscles in different species of animals as related to composition and (2) the effects of various chemical and physical treatments on the binding properties of meat proteins. Such information bears beneficially not only on the solution of problems in the manufacture of meat products but also, of course, on the production of all processed meats.

I hope these brief remarks have served to give you a sort of bird's eye view of our utilization activities on meat. The program is not large when viewed in the light of the size and value of the industry. However, it is our hope that through more extensive co-operation with many of the organizations represented here today we will be able to make even more useful contributions to the advancement of meat science and technology.